Project Report
EO-1-6

Earth Observing-1 Advanced Land Imager Flight Performance Assessment:

Investigating Dark Current Stability Over One-Half Orbit Period During the First 60 Days

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Abstract

The stability of the EO-1 Advanced Land Imager dark current levels over the period of one-half orbit was investigated. A series of two-second dark current collections every five minutes over the course of 40 minutes, was collected during the first sixty days the instrument was in orbit. Analysis of this data indicates only two dark current reference periods, obtained entering and exiting eclipse are required to accurately remove ALI dark current offsets for 99.4% of the focal plane. The analysis simulated a continuous Landsat data collection sequence over a period of one-half orbit.

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1 Introduction

The Advanced Land Imager (ALI) was launched on November 21, 2000 and is a technology demonstration for a possible future Landsat instrument[1-5]. Employing a pushbroom imaging method, the ALI does not have the luxury of observing periodic dark reference periods during each scan that wiskbroom imaging systems enjoy. As a result, dark current measurements of the ALI focal plane can only be performed when the aperture cover is closed, during eclipse, or when viewing deep space. Furthermore, under normal operating conditions, a Landsat type instrument will collect imagery for a great majority of the portion of the orbit illuminated by the Sun. To characterize the dark current stability of the ALI focal plane and hence the required frequency of dark current reference periods for Landsat class missions, a sequence of special dark current collections was performed during the first sixty days on orbit. This report documents the results of this dark current stability test.

2 Data Collection

The data collected for this study occurred on January 3, 2001. In preparation for this special dark current test, the focal plane was powered and allowed to warm-up for 4 minutes. Once thermally stabilized, the focal plane remained powered for over 40 minutes and two-seconds of data were collected every 5 minutes with the aperture cover closed.

3 Analysis

The mean dark current level of each detector of the ALI focal plane is determined for each of the nine dark current collections. A linear fit is then performed on each detector's dark current data. The fitted function is then subtracted from the original dark data and the mean and standard deviations for the *flattened* data are then calculated. Any detector with a standard deviation greater then 1.5 digital numbers is then categorized as a 'non-linear drifter'.

4 Results

The results of the thermal drift analysis are provided in Figures 1-12. For each figure, the overall linear drift and the standard deviation of the *flattened* data for each detector are provided. All VNIR bands and the Panchromatic band exhibited less than one digital number drifting during the forty minute period. These bands also exhibited residual drifting of less than 0.5 digital numbers, after linear drifting is subtracted. All SWIR bands exhibited up to 30 digital numbers of linear drifting. However, all but twenty-four SWIR detectors exhibited less than 1.5 digital number of residual drifting (Table 1). Twelve of these detectors were previously identified as exhibiting anomalous dark current or noise characteristics during ground calibration[6]. The distribution of SWIR detectors as a function of non-linear drifting threshold (0.5, 1.0, 1.5, 2.0, 2.5, and 5.0 digital numbers) is provided in Figures 13-15. Only the previously identified anomalous detectors exhibit non-linear drifting greater than 2.3 digital numbers.

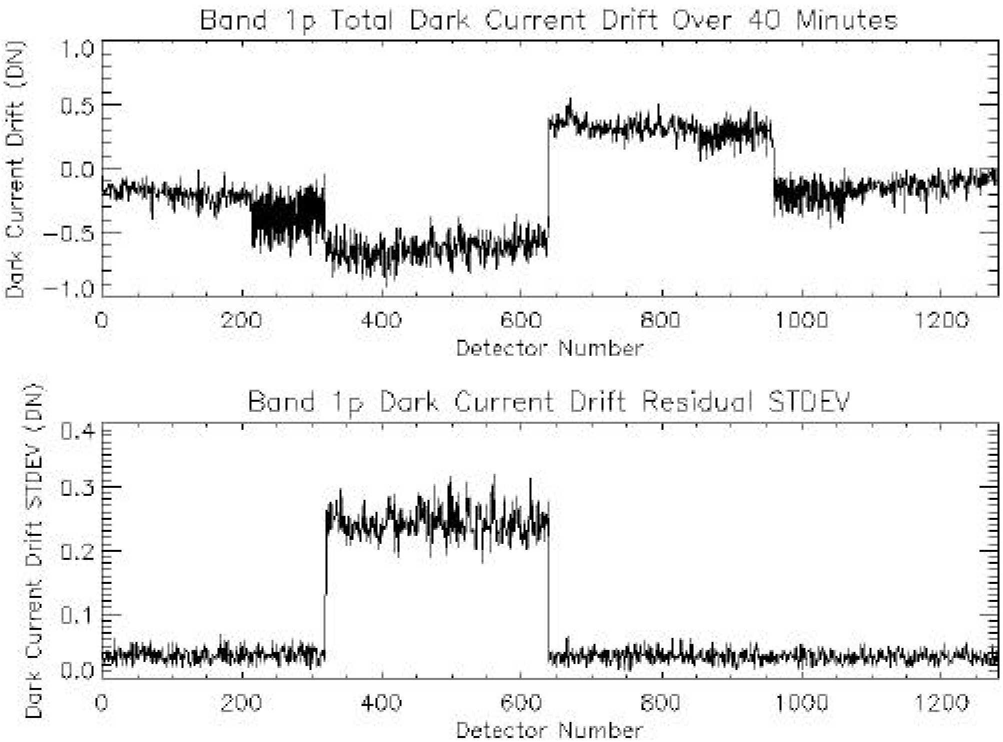

Figure 1: Dark current drift for Band 1p.

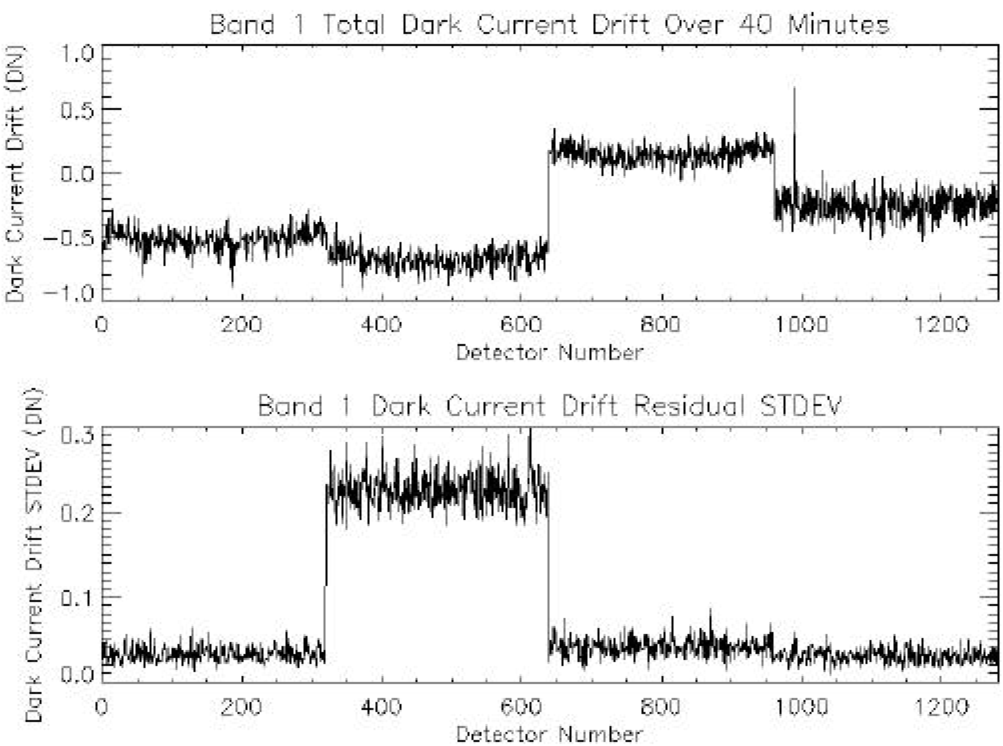

Figure 2: Dark current drift for Band 1.

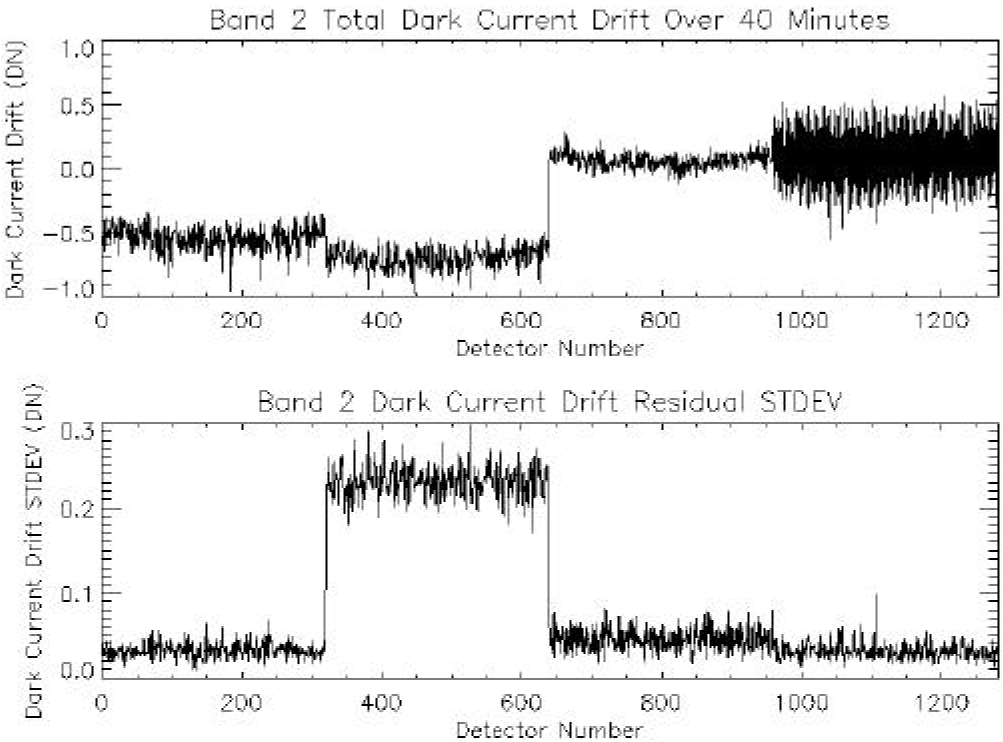

Figure 3: Dark current drift for Band 2.

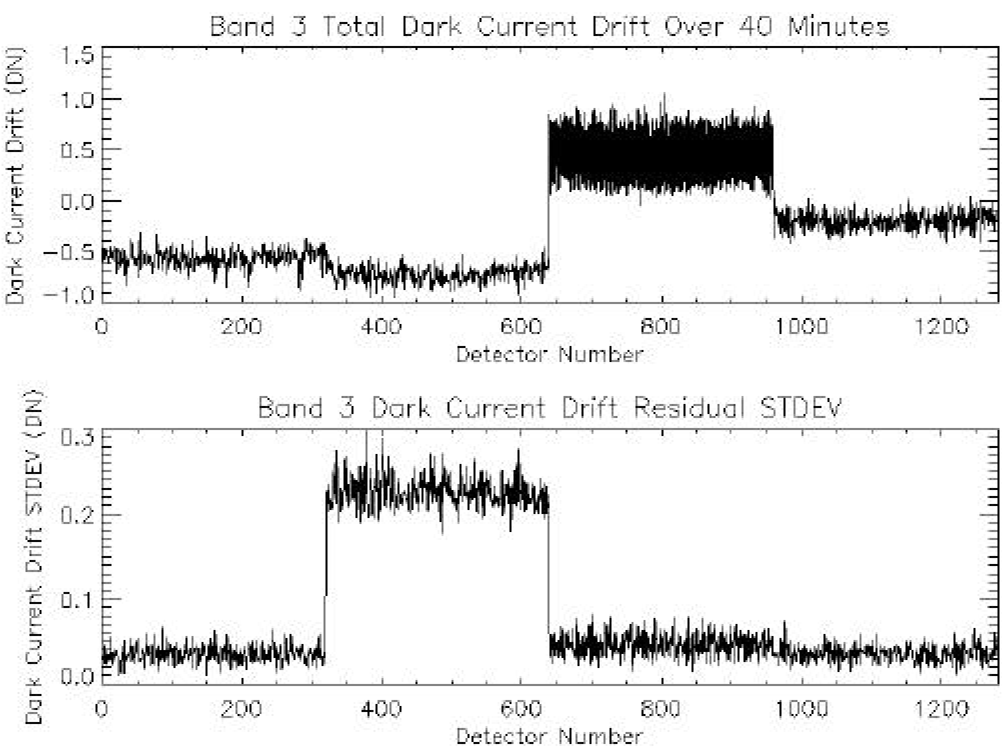

Figure 4: Dark current drift for Band 3.

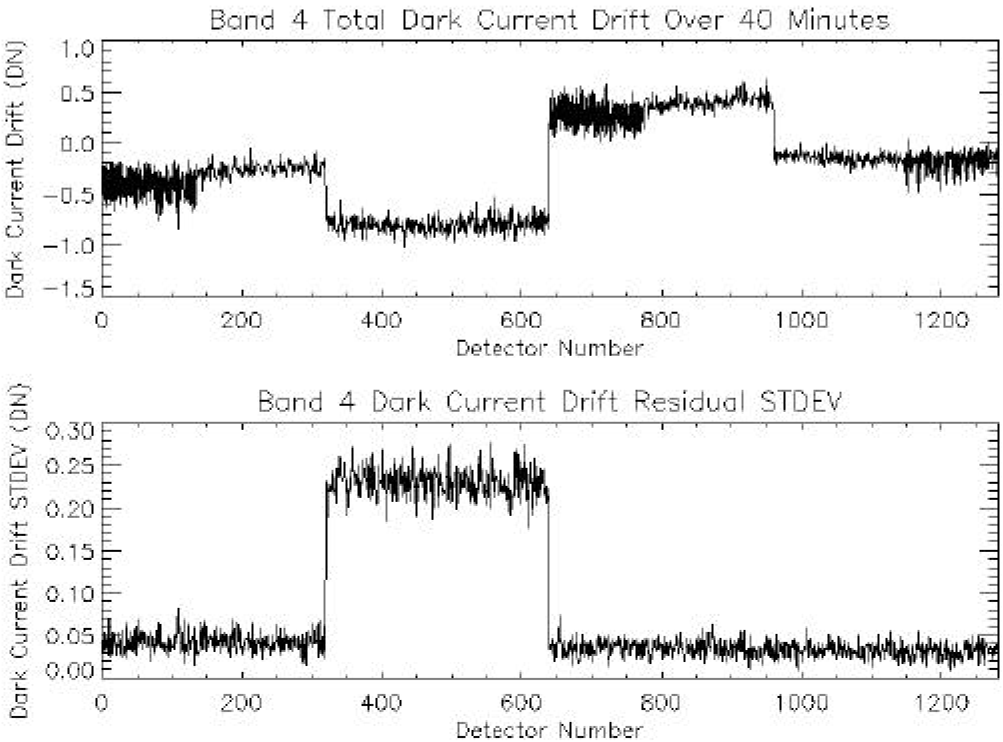

Figure 5: Dark current drift for Band 4.

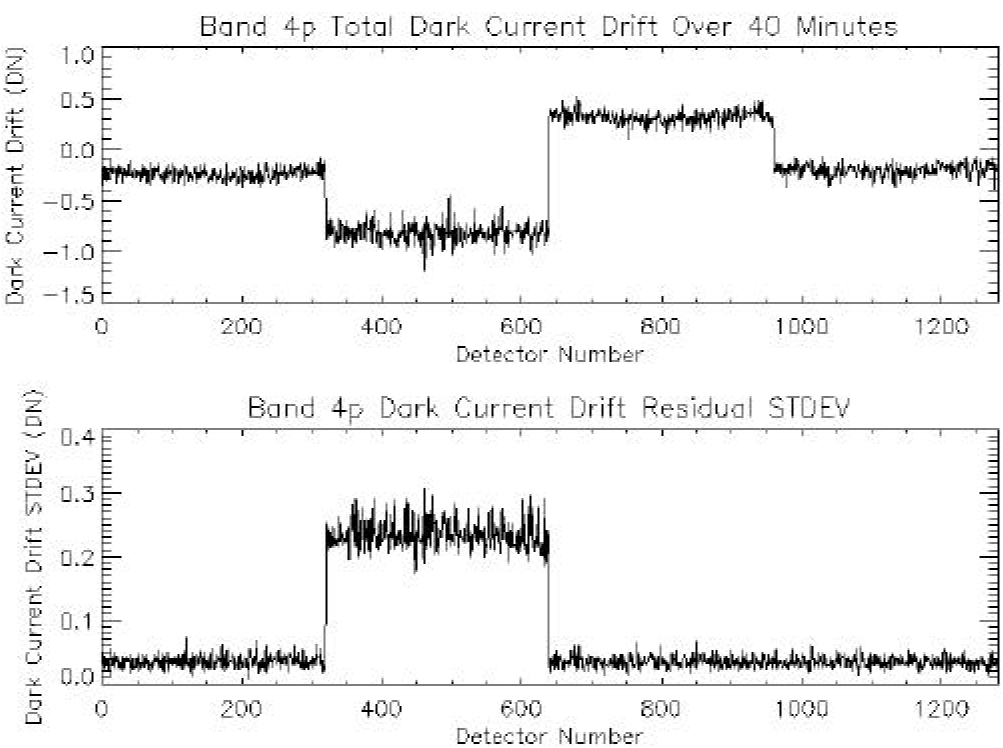

Figure 6: Dark current drift for Band 4p.

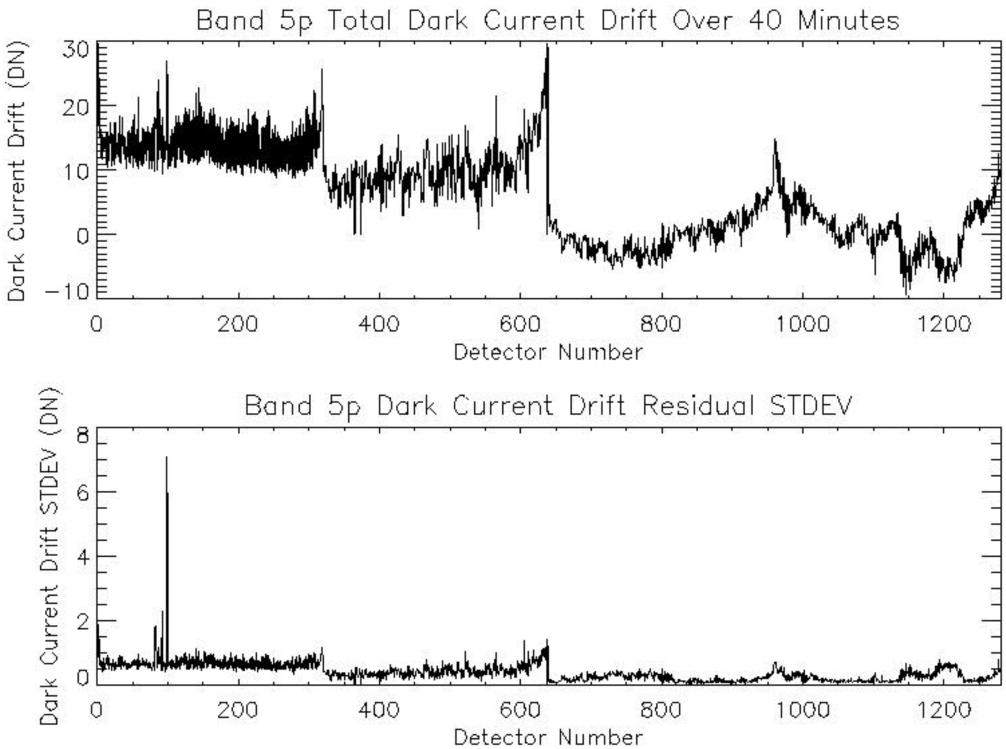

Figure 7: Dark current drift for Band 5p.

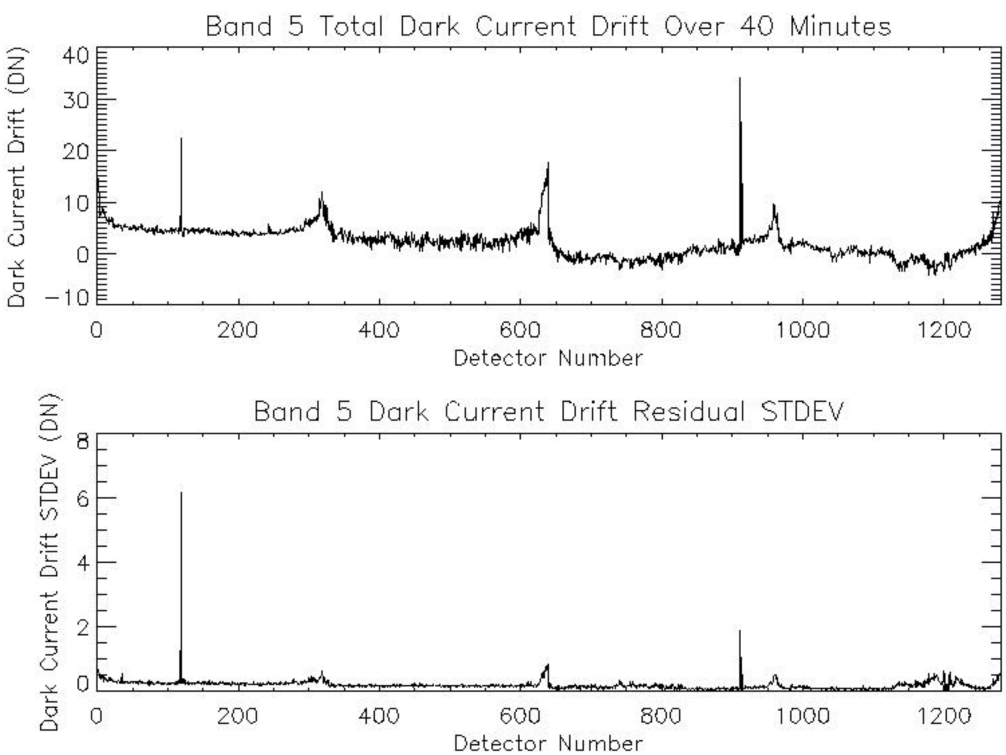

Figure 8: Dark current drift for Band 5.

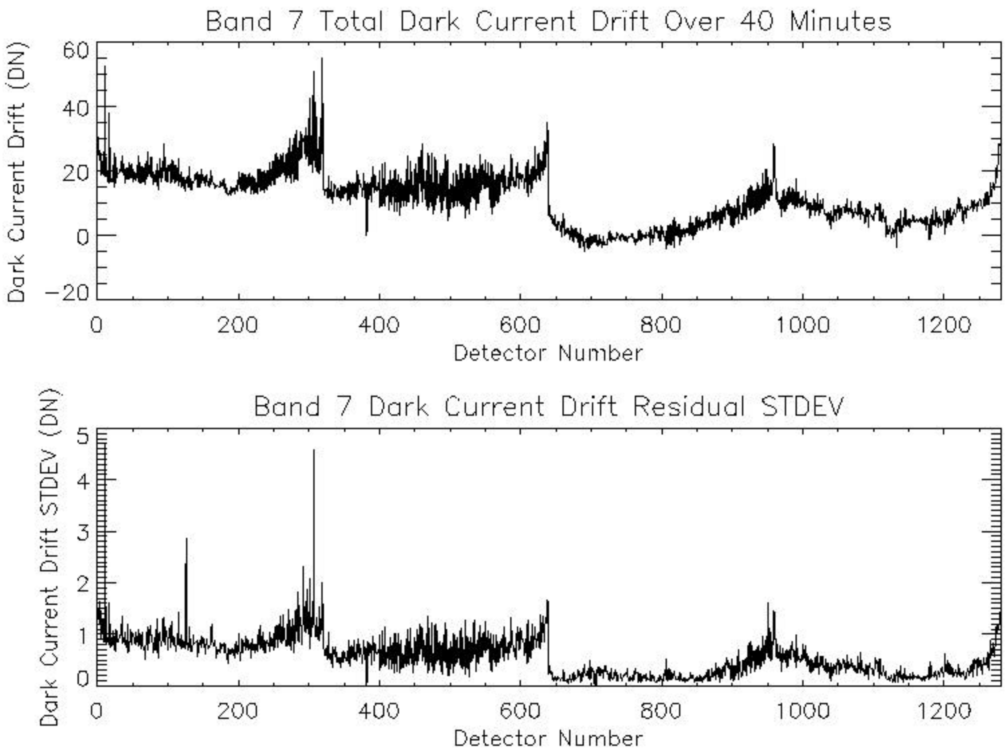

Figure 9: Dark current drift for Band 7.

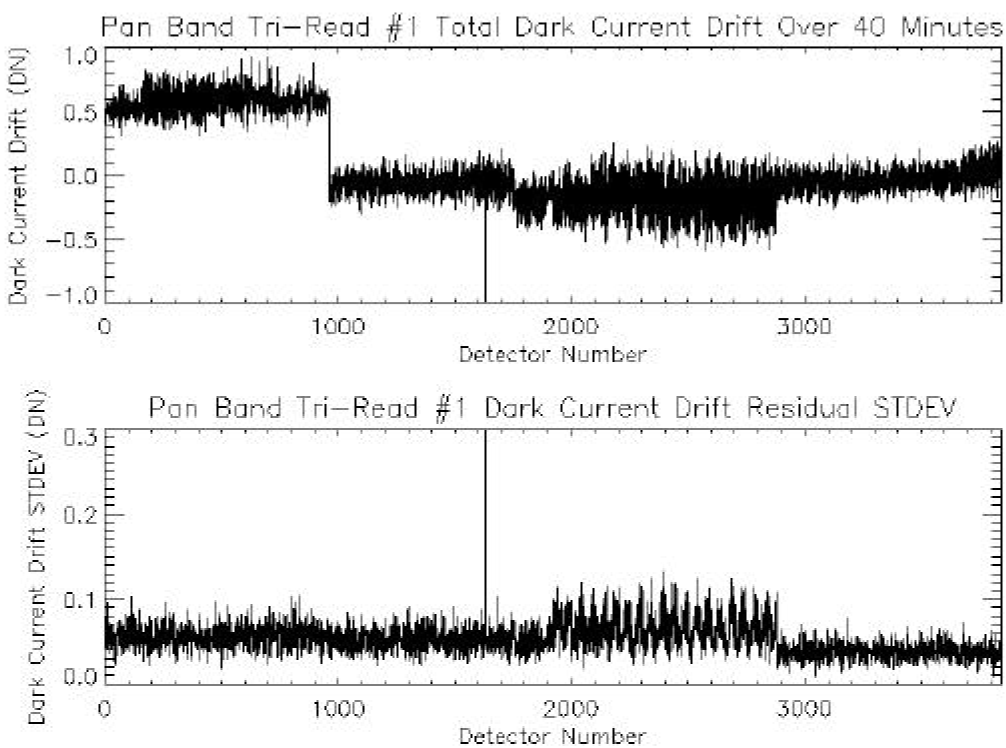

Figure 10: Dark current drift for Panchromatic Band tri-read #1.

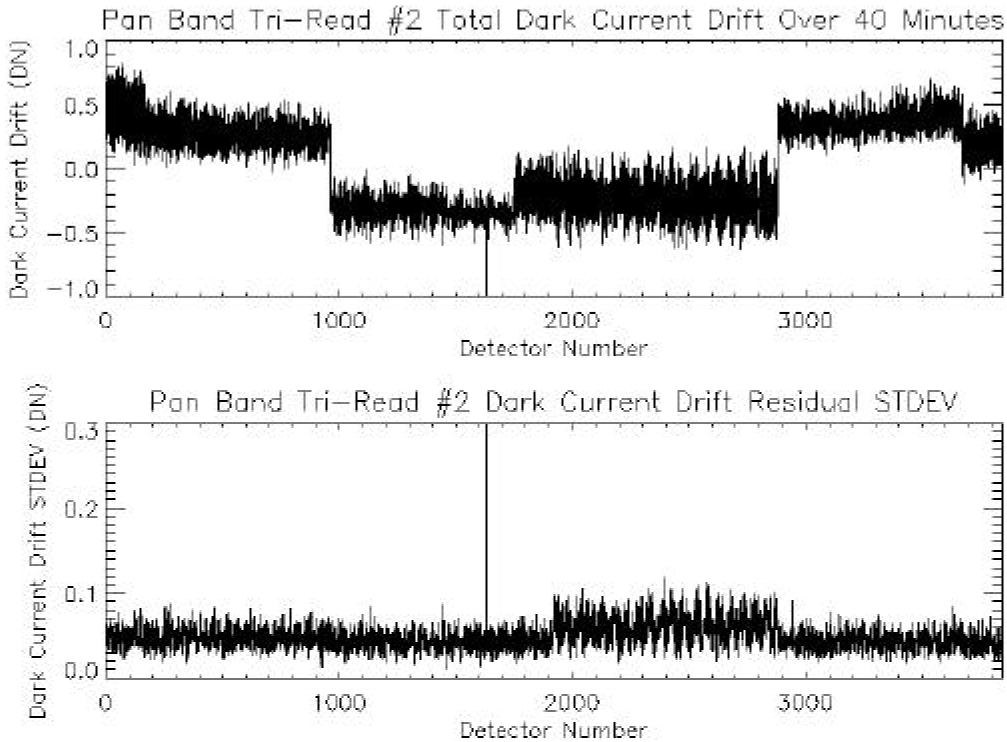

Figure 11: Dark current drift for Panchromatic Band tri-read #2.

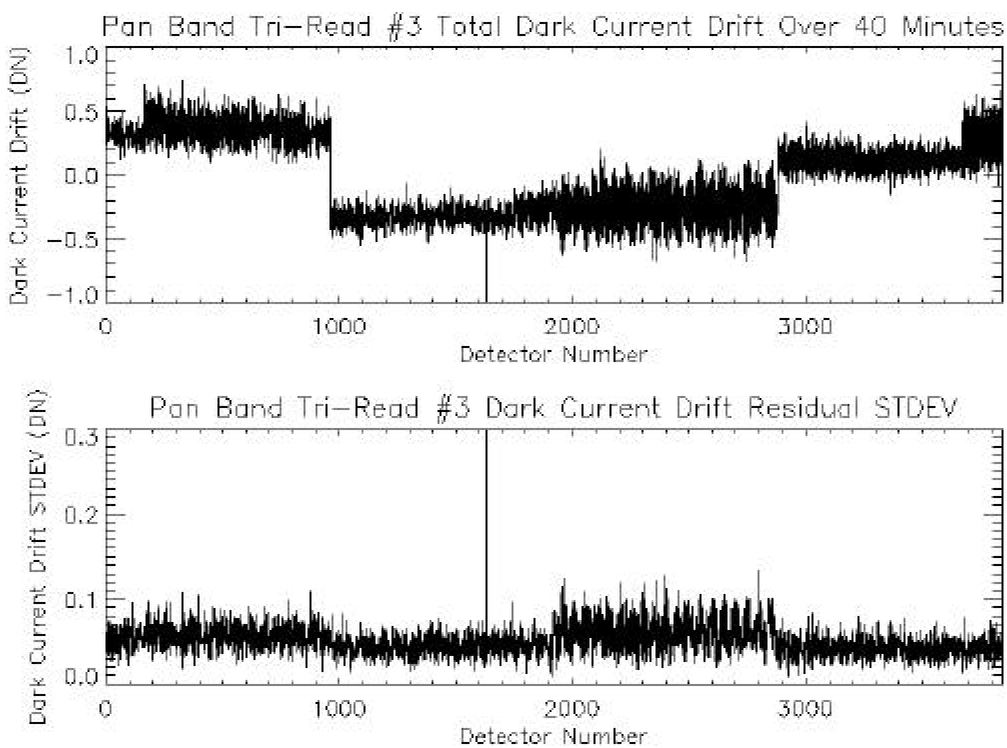

Figure 12: Dark current drift for Panchromatic Band tri-read #3.

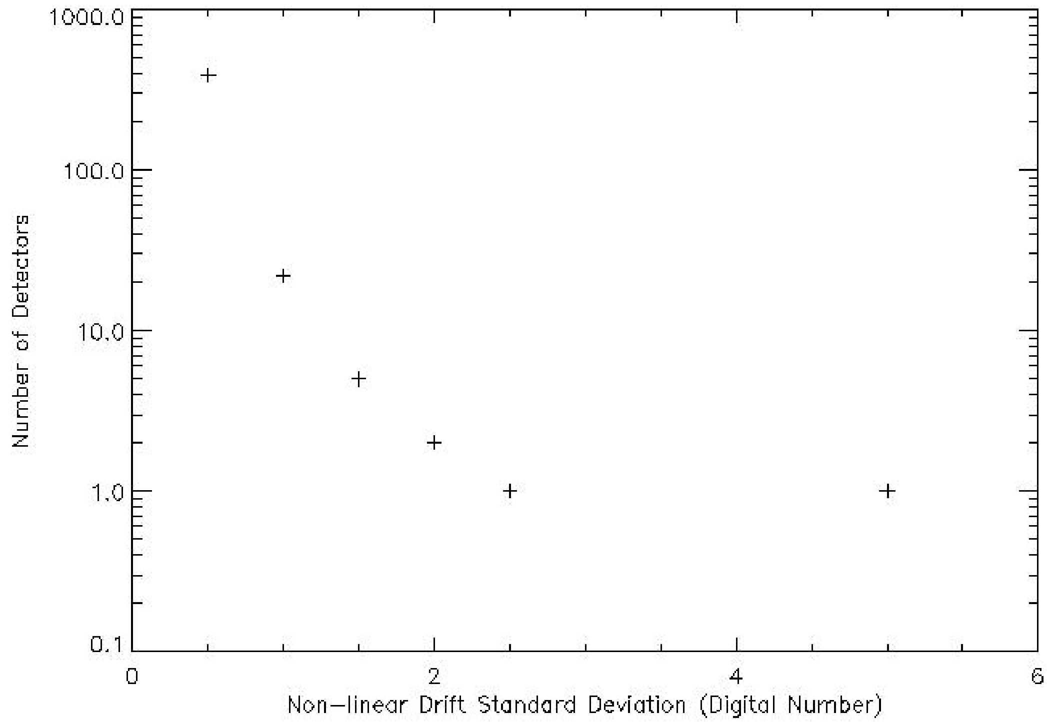

Figure 13: Dark current non-linear drift distribution for Band 5p.

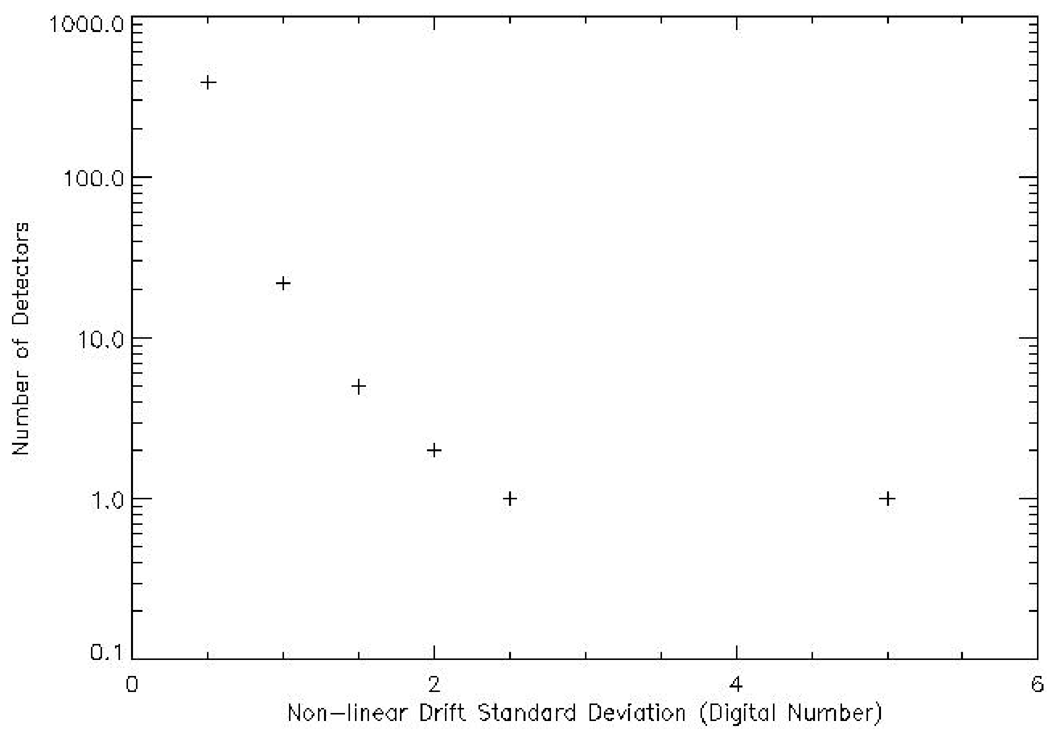

Figure 14: Dark current non-linear drift distribution for Band 5.

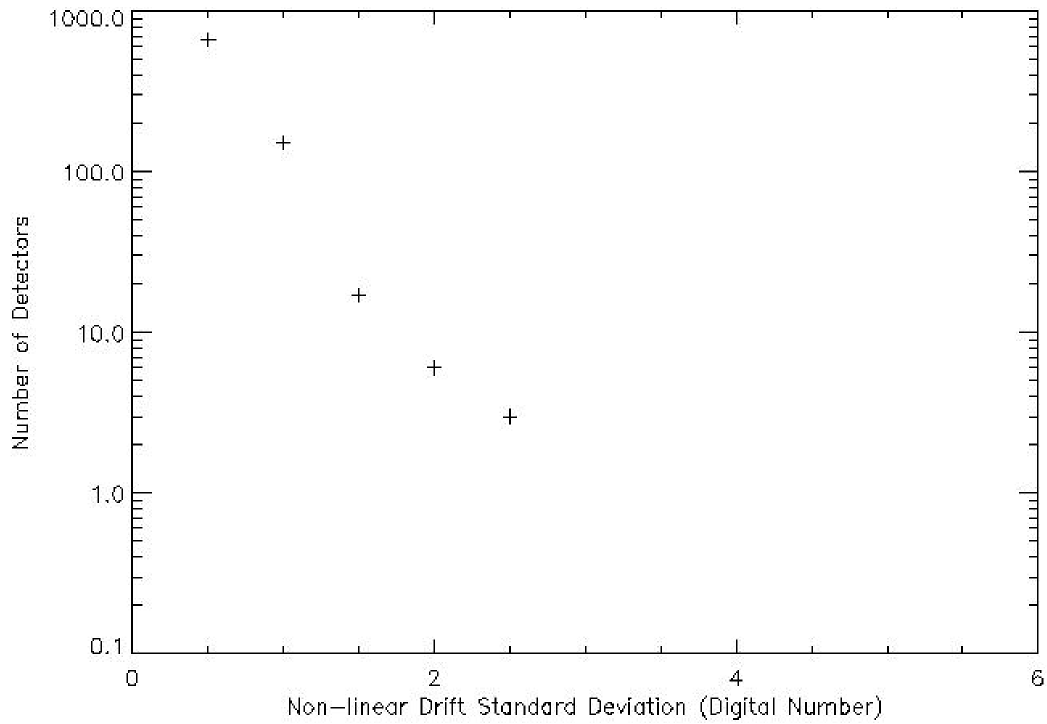

Figure 15: Dark current non-linear drift distribution for Band 7.

Table 1: Detectors with non-linear drifting greater than 1.5 digital numbers over a 40-minute period.

Band	Detector Number	Residual Drift (Digital Number)
5p	2	1.86
5p	82	1.77
5p	83	1.87
5p	92	2.28
5p	99	7.07
5	119	6.16
5	911	1.86
7	0	1.57
7	4	1.63
7	11	4.72
7	17	1.61
7	126	2.86
7	285	1.81
7	292	2.32
7	295	1.64
7	297	1.88
7	301	2.09
7	305	1.55
7	307	4.58
7	315	1.52
7	319	2.01
7	638	1.65
7	639	1.64
7	951	1.60

5 Conclusion

The above analysis indicates all of the active VNIR and Panchromatic detectors of the EO-1 Advanced Land Imager focal plane are stable to within 1 digital number over a period of forty minutes. However, all of active SWIR detectors exhibit some drifting during this period. Fortunately, 99.4% of these detectors drift linearly and may be easily accommodated through a linear interpolation of dark current measurements obtained as the instrument exits eclipse near the North Pole and enters eclipse near the South Pole. An additional 0.3% exhibit less than 2.3 digital numbers of nonlinear drifting over the 40 minute period. The worst detector drifts by 7.1 digital numbers but has been previously identified as having excessive white and pseudo-random noise[6].

The effect of non-linear drifting will result in the inaccurate subtraction of dark current levels during observations. This will become most evident in regions of poor illumination or low reflectivity (e.g. water). Figure 16 depicts the amount of uncertainty added to the radiometric accuracy of a detector as a function of counts for a non-linear drifting of 0.5, 1.0, 1.5, 2.0 and 2.5 digital numbers. This uncertainty will result in detector-to-detector striping which is dependent on the amount of signal produced by the scene and the amount of non-linear drifting by the detector.

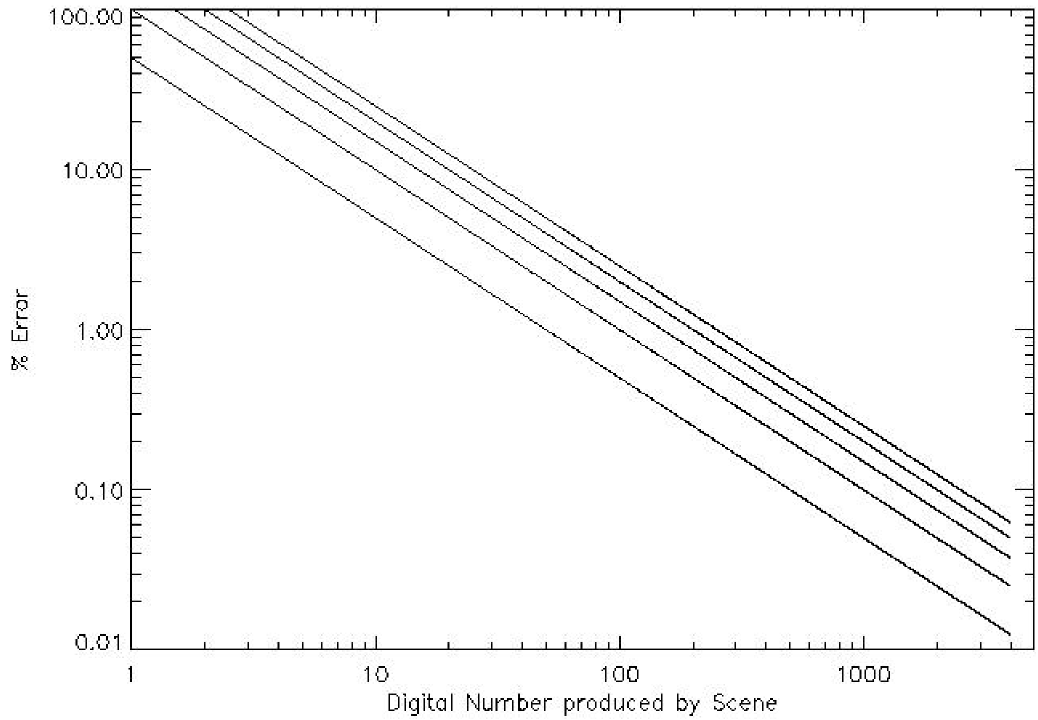

Figure 16: Effects of non-linear dark current drifting on radiometric accuracy of scenes. The curves (beginning at the bottom) are representative of 0.5, 1.0, 1.5, 2.0 and 2.5 digital numbers of non-linear dark current drifting.

Dark current drifting will continue to be monitored throughout the EO-1 mission in order to track the Advanced Land Imager's performance in this aspect as a function of time in orbit.

6 References

1. J. A. Mendenhall et al., “Earth Observing-1 Advanced Land Imager: Instrument and Flight Operations Overview,” MIT/LL Project Report EO-1-1, 23 June 2000.
2. D. E. Lencioni, C. J. Digenis, W. E. Bicknell, D. R. Hearn, J. A. Mendenhall, “Design and Performance of the EO-1 Advanced Land Imager,” *SPIE Conference on Sensors, Systems, and Next Generation Satellites III*, Florence, Italy, 20 September 1999.
3. W. E. Bicknell, C. J. Digenis, S. E. Forman, D. E. Lencioni, “EO-1 Advanced Land Imager,” *SPIE Conference on Earth Observing Systems IV*, Denver, Colorado, 18 July 1999.
4. C. J. Digenis, D. E. Lencioni, and W. E. Bicknell, “New Millennium EO-1 Advanced Land Imager,” *SPIE Conference on Earth Observing Systems III*, San Diego, California, July 1998.
5. D. E. Lencioni and D. R. Hearn, “New Millennium EO-1 Advanced Land Imager,” *International Symposium on Spectral Sensing Research*, San Diego, 13-19 December 1997.
6. J. A. Mendenhall et al., “Earth Observing-1 Advanced Land Imager: Dark Current and Noise Characterization and Anomalous Detectors,” MIT/LL Project Report EO-1-5, 23 February 2001.

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